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A modular approach to endurance loading of subsistence stores in Naval vessels.

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THESIS

A MODULAR APPROACH TO ENDURANCE LOADING
OF SUBSISTENCE STORES IN NAVAL VESSELS

by

Joseph Lee Palanuk

September 1980

Thesis Advisor: C.F.Taylor, Jr.

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A Modular Approach To Endurance Loading Of Subsistence Stores In Naval Vessels

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I. INTRODUCTION

A. ENDURANCE REQUIREMENTS

As part of strategic planning, U.S. Navy ships are charged with maintaining mission readiness by adhering to performance levels in each of several mission essential areas. In the area of supply, specifically subsistence items (dry and refrigerated foodstuffs), higher authority has established minimum endurance levels for each class of ship. Each ship must determine the types and quantities of subsistence items to load in meeting these levels. How subsistence loads should be determined under emergency situations is the subject of this thesis.

The significance of endurance levels on mission readiness is not restricted to subsistence loads. Inherent in the design of all U.S. Navy ships is the allocation of space for storage of fuels, food, repair parts and other material essential for support of men and equipment. Complex design factors are used to allocate space; balancing between operational spaces and material storage to support operations. The number of days that operations can be sustained using various materials represents the endurance capability of a ship. Thus, a ship may be capable of 15 days operations on fuel supplies, 30 days on food supplies and so on for each type of support material. Overall endurance capability varies by design between classes of ships and even within classes due to variations in consumption rates, design modifications or other factors. A Spruance class destroyer, for example, is designed for a different mission than a Vancouver class LSD. Consequently, the endurance

capability of the destroyer is not as great in food, fuel and other support areas. Additionally, two ships within the Spruance class may have slightly different fuel endurance due to differences in fuel consumption. In each class of ship, the capability to perform missions requires that attention be given to every aspect of endurance, not just subsistence. Reduced endurance capability in any material support commodity may seriously impair mission capability. The traditional labels of "Beans, Bullets and Black-oil" along with other support material are each a significant element in logistics support of naval forces.

While the concept of endurance is essential to all classes of naval vessels, for purposes of this study endurance data was confined to surface combatants, aircraft carriers and amphibious assault ships.

Although subsistence items represent less than 300 of the thousands of support items aboard ship, they have a significant impact on mission capability. In addition to providing the necessary personnel support, subsistence items require a significant investment of time, manpower and equipment in resupply efforts. Subsistence resupply for an aircraft carrier routinely involves the receipt and storage of 100 to 400 short tons of material. The evolution can span several days in port or six or more hours if accomplished at sea, and requires 600 or more manhours and several forklifts, cranes and other equipment. Add to this the breakout, palletization and delivery of material from the resupply activity and the investment of time, manpower and equipment nearly doubles. Subsistence resupply for smaller ships, although of a lesser magnitude, often becomes virtually an all-hands evolution to complete within given time frames. In each case, subsistence resupply

must compete with other demands for men, time and equipment. At sea, resupply diverts combatants away from primary mission areas, such as flying or gunfire support. In port, resupply competes with the demands of maintenance, personnel needs, limited shore support equipment and other readiness evolutions. Subsistence resupply, to fit within time constraints, often must be accomplished under less than optimum conditions. Loading may be required at a fuel pier, shipyard or even at anchorage. In an emergency, time and other constraints may play an even greater role in driving resupply operations. Near the end of the Viet Nam war, there were several occations when combatants were required by operational commitments to enter Subic Bay for resupply and emergency maintenance and return to sea within four hours. In such a situation, a resupply plan that will allow efficient loading of subsistence items can enhance overall endurance capability and minimize conflicts with other demands and constraints. Effective subsistence load plans can significantly add to a ship's total readiness posture by ensuring that maximum endurance can be attained in a minimum amount of time.

B. SUBSISTENCE LOAD PLANNING

Basic guidance for developing subsistence loads to meet established endurance requirements is the responsibility of the Naval Supply Systems Command (NAVSUP). Fleet and Type Commanders promulgate endurance levels and may, at various times, provide subsistence loading information relevant to a specific situation. However, such guidelines are usually the result of lessons learned and are not intended as general

planning factors for subsistence endurance loading. General guidelines are provided from NAVSUP for use in food management training courses and aboard ship. Reference 1 contains the basic guidance for subsistence load planning. Additional load planning guidance from NAVSUP and other sources will be discussed in Chapter III.

As noted in Reference I, the Navy Food Service System Office (FSSO), a branch of NAVSUP, has developed a subsistence endurance base load to assist ships with the planning of subsistence loads. The base load was developed recognizing the fact that normal operating stocks of subsistence contain a greater quantity of perishable and bulky items than is essential or feasible to maintain within each ship's storage constraints. Such items as frozen french fries, corn-on-the-cob and rock cornish hens add flexibility and ease to meal planning and meal preparation. Unfortunately, the amount of storage space required for each of these items compared with the number of meals they can provide is proportionately larger than similar more basic food items. For example, one meal serving 100 men french fries requires 35 pounds of frozen fries. Thirty-five pounds of french fries requires 1.365 cubic feet of storage space. A meal serving the same number of men mashed potatoes instead of frozen french fries requires only 6.125 pounds of dehydrated potato granules, requiring less than .183 cubic feet of storage. The use of dehydrated potatoes not only requires less storage space, it also allows critical freeze storage to be used for meat or other essential products. Consequently, the endurance base contains a list of hard core food items that is more austere than normal but fully capable of supporting highly satisfactory menu planning when resupply

schedules may be interrupted. This base can be adjusted to reflect differences in crew preference for certain foods. The basic load, as noted in Reference 1, along with accurately planned and properly maintained operating levels, can add up to prescribed fleet endurance levels for each ship.

In conjunction with subsistence load planning guidance, FSSO continually looks at new ideas, foods and trends and evaluates each for possible inclusion in the Navy subsistence support system. Over the years a number of subsistence items have been developed which have made contributions to improved subsistence endurance for U.S. Navy ships. Dehydrated foods like instant potatoes, powdered eggs and dry synthetic vinegar allow more endurance per package with less storage weight and cube. Freeze-dry technology has also added compressed peas, green beans and at least ten other light weight and low cube food items. Foods of this type are all considered ration-dense because of the large number of portions that can be prepared per unit weight and cube. FSSO has expanded the use of ration-dense items by developing ration-dense menus and load planning guides which incorporate ration-dense foods.

Further efforts of NAVSUP toward ensuring that fleet subsistence endurance levels are attained involve the availability of subsistence items for resupply. The FSSO provides input to the Federal Supply Catalog (Group 89) for subsistence items. These items are selected for use by naval forces by FSSO based on fleet demand and suitability for use and storage aboard ship. Subsistence items in the catalog are available from stock points in the United States and various other shore

locations around the globe. Additionally, ships of the Mobile Logistics Support Forces (MLSF) are designed to carry subsistence items for replenishment at sea. MLSF ships with subsistence resupply capability include combat store ships (AFS), fast combat support ships (AOE), replenishments oilers (AOR) and jumbo fleet oilers (AOJ). Fleet subsistence resupply capability has been further expanded on an as-needed basis by fitting portable refrigerated and dry storage units aboard ammunition ships (AE) and MSC fleet tankers (TAO). The latter have proven particularly adept as resupply escorts for surface combatant task groups deployed to the Indian Ocean and South Pacific. The MLSF is designed to extend the at sea capability of combat forces by eliminating the need to return to port for resupply. NAVSUP, through the Fleet Material Support Office (FMSO) and FSSO, publishes guidelines for subsistence load planning from MLSF stocks. The MLSF does not carry the full range of subsistence items available in the system, but stocks a prescribed load of chill, freeze, and dry subsistence. Items included in the MLSF load are based on fleet wide demand. Loads for TAOs and AEs are generally tailored for supplemental support of a specific task group and include additional stocks of items carried in endurance loads in each combatant. Reference 2, Consolidated Afloat Requisitioning Guide Overseas (CARGO) is the publication used to provide subsistence resupply planning guidance to the Pacific Fleet. A corresponding publication is used by the Atlantic Fleet. For purposes of this study, only data from the Pacific edition were used.

II. NATURE OF THE PROBLEM

As principle logistics agent for Commander Seventh Fleet and as Type Commander for Mobile Logistic Support Forces in the Western Pacific, Commander Task Force Seventy-Three (CTF 73) develops detailed support plans for naval task groups on special missions to Indian Ocean, Northern and Southern Pacific areas. Because of the limited resupply opportunities in these areas and the desire to project the image of self-sufficiency, logistic support plans require each ship to maximize endurance as much as practicable. Subsistence support plans include guidelines on the use of ration-dense foods, availability of indigenous food items in an area and proper storage space utilization. Although somewhat similar in concept, each plan is designed around a specific mission. A plan requires several weeks to develop. On more than one occasion in the recent past, the emphasis on self-sufficiency has been a key to mission accomplishments.

Between 1971-72 and again between 1977-79, world events caused several task groups on special missions to the Indian Ocean to be extended beyond original plans. Endurance until resupply could be rescheduled became a critical issue. Task Force Commanders were required to report the endurance capability of each ship under their command for all critical material support areas including subsistence. Had prior planning and maximum endurance not been emphasized as part of the pre-deployment work, mission capability might have been severely impaired.

With the exception of special missions, however, Navy ships are routinely expected to be capable of responding to contingencies without the aid of special logistics plans. As noted above, Fleet Commanders provide endurance levels to be maintained and NAVSUP provides guidance on accomplishing endurance loading. Whether this guidance is sufficient to ensure that all ships can respond to endurance load requirements in a contingency is questionable. Experience at CTF 73 has shown that the ability to rapidly and efficiently load can vary significantly with the knowledge and experience of the personnel involved. For a Commanding Officer or Task Group Commander, endurance is just one of the readiness areas that will be of concern in an emergency. If personnel responsible for subsistence endurance loading lack experience or guidance, mission capability could be impaired.

The following chapters will look at current endurance load guidance, propose additional guidance and evaluate the significance of subsistence endurance loading on a ship's mission capability.

III. EXISTING LOAD PLANNING GUIDANCE

A. DESCRIPTION

With the exception of special logistic support plans for individual missions, general guidance for subsistence load planning comes from NAVSUP Publication 486 [Ref. 1]. Endurance considerations are included as part of the general guidance of chapter three of Ref. 1. The use of this and other guidance by supply officers or food service personnel for subsistence load planning is detailed below.

The first step in subsistence load planning is to determine the readiness posture of the ship and the expected endurance levels prescribed for that posture. As noted earlier, Fleet and Type Commanders prescribe minimum endurance levels for each class of ship. Levels are based on current or anticipated operations. Thus, a ship in overhaul may be required to maintain 30 days endurance or none at all if the crew is not being fed on board, while a deployed ship may be required to maintain 90 days endurance. Planning personnel review the appropriate operational order to determine the required endurance levels. As an example, a ship deploying to the Western Pacific may be required by Commander in Chief Pacific Fleet to maintain a minimum of 45 days freeze and 60 days dry subsistence while deployed. Specific requirements vary for individual classes of ships and will not be presented here due to security classifications.

Once readiness posture and minimum subsistence endurance requirements have been established, a subsistence load is developed. This

load must satisfy both endurance levels and menu planning requirements. The experienced load planner will use prior experience and the guidelines of Ref. 1. The inexperienced planner will have to rely solely on Ref. 1 and other guidelines. For purposes of this study, it is assumed that prior experience is not available.

Critical to the development of a subsistence load are the storage constraints aboard a particular ship. The load planner would consult the ship's general plans to determine the gross storage cube available in each category of subsistence storage space (chill, freeze and dry). Gross cube is the total storage space in cubic feet without regard for ladders, vents, pipes, dunnage or air circulation. This information should be kept in load planning files for initial and all subsequent loadouts. As modifications are made to storage spaces due to ship alterations, gross storage cube figures should be changed. Gross cube must be reduced by a factor which considers proper storage and stock rotation. This will be the actual cube available for loading. Air circulation, dunnage, stock rotation and other storage considerations can reduce gross storage space as much as 55%. Space constraints aboard some ships do not always allow rigid adherence to proper storage techniques if minimum endurance levels are maintained. However, proper subsistence storage guidelines should be followed as closely as practicable. References 1 and 4 both provide guidelines for proper subsistence storage. Because subsistence loads are part of the ship's designed weight characteristic, the total weight of subsistence to be loaded is not as significant as total cube. However, as a matter of routine, the load planner should consult with the damage control assistant prior to any significant shifts in weight due to subsistence loading.

From P-486 [Ref. 1], the load planner develops his basic endurance load (BEL). Reference 1 provides a table of basic food items that can be carried in a BEL. The BEL is based on subsistence support for 100 men for 45 days. The load planner adjusts the BEL to account for the number of crew on board. If there are 500 enlisted crew, then quantities in the BEL are multiplied by five. Quantities and items may also be adjusted to reflect crew tastes and storage capacities aboard a particular ship. The BEL recognizes that storage spaces aboard most ships are not adequate to hold prescribed endurance levels of subsistence composed of items carried under normal replenishment operations. Bulk items, such as spareribs, pizza crust and ice cream cups do not supply endurance levels commensurate with the space they require. The load planner uses the BEL as the base of his subsistence load and adds to that endurance base the operating level quantities of the BEL items. BEL operating levels reflect a ship's normal consumption and are equal to the quantities necessary to support a specific menu during the time lapse between replenishments. For example, 75 days prescribed endurance minus 45 days BEL equates to 30 days operating level. Operating levels for non-BEL items, defined below are also used in determining endurance levels. As noted in Chapter 1, the BEL coupled with accurately planned and properly maintained operating levels will add up to fleet endurance levels.

In addition to the BEL, Ref. 1 provides a meal summary table which allows the planner to develop sound menus in conjunction with planning the endurance load. Summary data on the number of meals that can be served from each subsistence item in the 45 days BEL are

given. For example, the BEL contains 24 No. 10 cans of fruit cocktail. Four cans per 100 portions are required for each meal which allows menu planning for three breakfasts and three dinners. With the aid of the meal summary, the load planner can develop his own BEL that considers crew preferences and menu planning as well as minimum endurance levels.

Cycle menus are used in conjunction with BEL and meal summary data [Ref. 1] for subsistence load planning. A cycle menu details meal planning over a period of time and then repeats itself. A cycle can be of any length but most are 21 days based on guidelines in Ref. 1. By using the cycle menu, exact quantities of each food item needed to support one cycle can be determined. Menu support items can be included in the BEL or normal operating stocks. A cycle menu using primarily BEL items would allow more endurance than one relying on normal operating stocks.

After determining individual items for the BEL, the planner determines inventory high and low limits for each of the items in the BEL. Exhibit I from Ref. 1 illustrates the steps involved in determining high and low limits for a BEL item. Similar computation is done for each item with highs and lows being posted to individual stock record cards. These computations do not guarantee that the load will fit on board.

The planner must next establish high and low limits for each of the non-BEL items to be carried. As noted above, it is not feasible to maintain all bulky or perishable items in the subsistence load. However, there are items that are desirable to stock when operations permit regularly scheduled resupply. Such items as spareribs or beef round

EXAMPLE
of

Computation of Low Limit, High Limit, and Requisitioning Objective for Canned Precooked Bacon (for Stockage in Basic Endurance Load)

Planning Factors

Prescribed Endurance (PE): 75 days

Varies. PE established by Fleet and Type Commanders.

Basic Endurance Level (BEL): 45 days

Suggested BEL 30-45 days. Determined by prescribed total endurance and ship's stowage capacity

Low Limit (LL) for BEL items: 45 days

See above note on BEL. For basic endurance loaded items, LL is the same as BEL.

Operating Level (OL): 30 days

(i.e., 75-day PE minus 45-day BEL). Quantity to support a specific ship's menu during time lapse between replenishments. Reflects ship's normal consumption.

Order and Shipping Time (O&ST): 21 days

Time lapse between submission of requisition and receipt of item. Expected issues during O&ST must be added to HL for RO computation below

High Limit (HL): 75 days (45-day LL + 30-day OL)

Same as PE

Requisitioning Objective (RO): 96 days (75-day HL + 21 day O&ST)

Level to which requisitions must bring stocks to support PE, plus expected issues between submission of requisitions and receipt of item.

Number of men supported by BEL: 320

Normal usage of BEL item (canned bacon) under normal replenishment: 120 cans/month

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Low Limit Computation
(for above Planning Factors)

45-day LL, Canned Precooked Bacon for 100 men = 87 cans
(45-day SEB level from subpar a)

45-day LL, Canned Precooked Bacon for 320 men = 278 cans
(3.2 x 87 cans)

High Limit Computation
(for above Planning Factors)

75-day HL, Canned Precooked Bacon for 320 men = 398 cans
(278 cans (45-day LL) + 120 cans (30-day OL))

Requisitioning Objective Computation
(for above Planning Factors)

96-day RO, Canned Precooked Bacon for 320 men = 482 cans
(398 cans (75-day HL) + 84 cans (21-day O&ST))
(21-day O&ST = $\frac{21}{30}$ x 120 (normal usage/month))

NOTE: Round off all LL, HL, and RO computations to case lots. Frequent review and revision of LL, HL, and RO is required to maintain readiness stocks at levels which accurately reflect usage and resupply schedules.

allow expanded menu planning and enhance crew morale. Low limits for these non-BEL items should represent usage between replenishments; for example, 14 day levels for bi-weekly replenishments and 30 day levels for monthly resupply schedules. High limits for these items are set based on operating levels (usage plus order and shipping time). Because order and shipping time varies with changing schedules and supply sources, the subsistence load planner must frequently review high and low limits of each item and adjust limits as necessary. Exhibit II is an example of the high and low limit computations for non-BEL items.

In addition to the guidance of Ref. 1, the load planner can find supplemental guidance in References 4 and 5. NAVSUP Publication 421 [Ref. 4] provides additional menu planning ideas as well as subsistence storage considerations. NAVSUP Publication 346 [Ref. 5] provides menu planning and loading aids for use aboard surface ships with prescribed endurance of less than 45 days or feeding 99 or fewer men. A 20 day cycle menu in the publication can be used to plan endurance loads when usage data are not available.

Once high and low limits have been established on all subsistence items, both BEL and operating items, attainment of adequate subsistence levels becomes a task of ordering and receiving stores at scheduled resupply intervals. Prior to scheduled resupply, the quantities necessary to bring each item up to high limits is computed. These requirements are then forwarded to the resupply activity in sufficient time to allow for processing and delivery of material. Normally, five working days are required by a supply activity, however, emergency resupply can and

EXHIBIT II

COMPUTATION OF LOW LIMIT AND HIGH LIMIT FOR

PORK SPARERIBS

PLANNING FACTORS

NORMAL USAGE — 150 lbs every 30 days
(based on current cycle menu)

REPLENISHMENT CYCLE — 30 DAYS

ORDER AND SHIPPING TIME (O&ST) — 14 DAYS (BASED ON ADVANCED RESUPPLY REQUIREMENTS SUBMISSION TO MLSF)

- -

LOW LIMIT: USAGE BETWEEN RESUPPLY = 50 lbs

HIGH LIMIT: $\frac{\text{14 DAY O\&ST}}{\text{30 DAY RESUPPLY}} \times 150 = 70$ lb plus

150 lb NORMAL USAGE = 220 lbs

has been accomplished within hours given sufficient manpower and equipment resources. Resupply load planning for replenishment at sea is aided by the use of NAVSUP Publication P-4998 (CARGO) [Ref. 2]. The subsistence requisitioning tables of Ref. 2 provide planning factors for quantities and storage space requirement for each subsistence item carried by the MLSF. Exhibit III is an example of a subsistence requisitioning table from Ref. 2. Case and unit pack data, as well as weight and cube factors, are provided for resupply load planning.

B. DISCUSSION

There are several problems associated with using existing subsistence load guidance, as described above, for subsistence loading in an emergency situation. Perhaps most significant is the pre-planning and learning curve inherent in the system. In an emergency, there might not be sufficient time to develop an endurance load, and the quality of a load developed under time constraints would depend heavily on the experience of the personnel involved. This is not to suggest that a significant amount of endurance load planning does not go into predeployment work. However, endurance loads for routine deployments are based on a combination of BEL and normal operating items, as noted above. Subsistence inventory levels established under this guidance are designed to attain minimum fleet endurance levels and not necessarily maximize endurance. The observed tendency in a contingency situation is to top off subsistence items to high limits. This would include normal operating stocks which require additional storage space

SUBSISTENCE REQUISITIONING TABLES
(Top figure, No. cases - bottom figure, Unit of issue quantity)

Food Item Code	Nomenclature/NSN	U/I	Net/CS Wt Pack	Cube/CS CS/Pallet	MAN DAYS A 2,500	B 5,000	C 9,000	D 15,000	E 18,000	F 21,000	G 30,000	H 75,000	I 90,000
	DRY MEAT, POULTRY, AND FISH												
A02	Bacon, sliced precooked 8905-00-582-1330	CN	33 24	1.05 42	1 24	1 24	1 24	2 48	3 72	3 72	4 96	11 264	13 312
A06	Beef chunks, w/ natural juices, 29 oz 8905-00-926-6196	CN	45 24	1.12 30	1 24	1 24	1 24	2 48	3 72	3 72	4 96	11 264	13 312
A08	Chicken, boned, 29 oz 8905-00-753-6106	CN	44 24	1.23 30	1 24	1 24	1 24	2 48	3 72	3 72	4 96	11 264	13 312

but do not significantly add to endurance. Actually increasing subsistence endurance above prescribed levels requires knowledge of the maximum storage capacity of the ship and a plan for achieving maximum storage space utilization.

Time is another factor which might preclude the use of existing subsistence load guidance in an emergency. Given that a load plan has been developed using P-486 and other guidance, in an emergency it would require several hours at the minimum to determine resupply requirements and prepare material requisitions. There are additional time lags if the resupply requirements are transmitted by message. Preparation of an emergency load of subsistence using existing guidelines may require more time than is available, particularly if engineering, weapons or other operational readiness requirements are to be met in the same time frames.

A final comment on using existing guidance to develop emergency subsistence loads centers on recent trends. Concern over personnel retention and morale in the Navy has led to some dramatic changes in food service operations in the past several years. Twenty years ago, the need to conserve space and weight aboard naval ships fostered research and development of ration-dense foods and other innovations designed to improve endurance loading capabilities. Today the emphasis is on increasing the types and varieties of foods served. Specialty and ethnic foods were introduced first, and now fast food operations are being introduced to the fleet. These changes have added new subsistence items to the support items to be stored aboard ship. While these innovations may add significantly to improved crew morale, they

are not designed to enhance endurance. In the interest of readiness, it would only seem prudent to have plans for expanding subsistence endurance in a contingency.

In this Chapter, subsistence loading guidance currently available for development of subsistence loads has been presented. In applying this guidance to emergencies, several apparent deficiencies have been noted. The proposed endurance load plan presented in the following Chapter is one possible approach to elimination of these deficiencies.

IV. PROPOSED ENDURANCE LOAD

A. DEVELOPMENT

The previous Chapter discussed the technical considerations and steps involved in load planning using existing subsistence loading guidance. Initial load building and resupply planning performed under these guidelines are typical of the material readiness effort expected from food service management aboard any U.S. Navy Ship. Because of the somewhat predictable pattern of fleet operations and the experience of key personnel in planning for various fleet operating schedules, subsistence load planning and resupply often become almost routine in nature. For example, in preparing for local operations or deployment, experienced personnel use historical data and experience to develop subsistence requirements, order and receive material. As a matter of course, prescribed fleet endurance levels are maintained in this system. This situation is unquestionably the norm throughout the fleet. There are, however, situations that arise that do not fall within the category of routine, and often there is no previous data or experience available with which to determine the best course of action. Events in the Persian Gulf and Indian Ocean between 1979-80 are the most recent examples of non-routine operations that added new experiences and considerations to fleet support plans. The uncertainty of the length of operations and the very limited support in the area placed increased emphasis on the endurance of men, machinery and supplies and forced new thinking about resupply channels to the area. In such

situations what is needed is sound contingency plans that will provide even the most inexperienced personnel with the tools to attain maximum readiness in all mission areas.

This Chapter describes a system which would allow food service or other personnel, regardless of experience, to respond to any contingency with an effective subsistence load, a load that is designed to maximize subsistence endurance and thereby enhance mission readiness. This system was developed as a supplement to existing load planning guidance to reduce the risk of ineffective loads which might occur due to lack of knowledge, experience, time or a combination of these and other factors. It is an attempt to reduce this element of risk or uncertainty to a minimum.

The proposed endurance load plan uses the concept of a modular load. That is, it is designed around a basic list of food items similar to the BEL of Ref. 1. However, unlike Ref. 1, the proposed endurance load provides planning for meals and menus solely on the items listed in the module (2 chill, 25 freeze and 94 dry items). Normal operating subsistence items would be considered in meal planning only if they were already on board prior to loading for endurance. Like the BEL of Ref. 1, the modular load provides subsistence support for 4,500 man days (100 men for 45 days). An endurance load for a specific ship would be made up of multiples of the basic module. For example, a ship might have a storage capacity five times larger than the storage space requirements of the modular load. Assuming no subsistence is currently on board, load requirements would be equal to five times the quantities listed for each item in the modular load. Due to differences

in available space, the load multiple for freeze and dry items would rarely be equal. For example, the load multiple for freeze might be 2.5 while the multiple for dry might be 4.0. In such instances, two options are available. The smaller of the multiples could be used to determine load requirements or each factor could be used independently to determine requirements for each of the storage categories. Using the smaller multiple has the possible disadvantage of leaving unused storage space in the commodity with the larger multiple (freeze or dry). This space could, however, be filled by adding additional items to the load or by increasing load quantities of key items in the modular load. The experience of food service personnel would be a factor in determining which items to increase.

Primary consideration for the modular load was endurance effectiveness. Effectiveness was measured in terms of the amount of endurance per cubic foot of required storage space. A 45 day subsistence load that requires 200 cubic feet of storage is considered less effective than a similar load that requires only 190 cubic feet of storage. The basic assumption is that efficient use of available space will allow the storage of more material and, therefore, greater endurance.

Modifications to the BEL [Ref. 1] were made while retaining the same menu planning capability as outlined in Ref. 1. Items in the BEL were compared against subsistence items listed in CARGO.[Ref. 2]. Non-CARGO items in the BEL were replaced with CARGO items to ensure that the endurance load is capable of being supported from the MLSF. Each food group listed in CARGO was reviewed and items or quantities were modified to maintain the same menu-planning balance provided by

the BEL. Ration-dense conversion factors were used to equate some CARGO items with the BEL. Some examples of these factors are presented in Exhibit IV. Since CARGO is updated based on fleet demand, the use of CARGO ensures that items in the load reflect current fleet preferences. Where feasible, substitute items were identified to allow adjustments for crew tastes. The two chill storage items listed in the BEL (Pullman ham and cheddar cheese) were used in the modular load without modification. Storage space requirements for these two items (8 cubic feet) was not considered a significant factor in load planning. Subsequently, no evaluation of the endurance effectiveness of these two items was done. The endurance effectiveness of freeze and dry items in the modular load is evaluated in the next Chapter.

Items contained in the modular load are listed in Appendix A. For emergency loading, the load factor for both dry and freeze items would be computed. Load factors are derived from the following formula:

$$\text{LOAD FACTOR} = \frac{\text{NET STORAGE CUBE}}{\text{MODULAR LOAD CUBE}}$$

Net storage cube can be determined by subtracting the appropriate number of cubic feet required for overhead clearance, aisles, obstructions or other proper storage considerations from the gross cube in each storage space. The approximate cube of existing inventories should also be subtracted from the gross cube. If there are several storage spaces designated for a commodity (freeze or dry), then the net storage cube for each space should be added together. For example, net storage in two different freeze spaces might be 100 and 50 respectively.

8. SUBSTITUTION FACTORS FOR RATION-DENSE FOODS. The following table lists the substitution factors for ration-dense food items. The factors listed in column E will be used to compute the quantities of conventional foods required to replace known quantities of ration-dense foods. The factors listed in column F will be used to compute the quantities of ration-dense foods required to replace the known quantities of conventional foods. The factors listed in columns E and F permit direct conversions to standard units of issue.

EXAMPLE

Quantity of egg mix, dehydrated (ration-dense)	x	Factor (column E)	=	Equivalent quantity of shell eggs (conventional)
55 No. 3 cyl CN	x	3.46	=	190.30 DZ

SUBSTITUTION FACTORS FOR RATION-DENSE FOOD ITEMS

Ration-dense food items	Unit of issue	Conventional food items	Unit of issue	Substitution Factors: Ration-dense to conventional (B x E = D)	Substitution Factors: Conventional to ration-dense (D x F = B)
A	B	C	D	E	F
Apples, dehydrated, pie style	#10 cn	Apples, sliced, canned	#2 cn	9.226	0.108
Apples, dehydrated, pie style	#10 cn	Apples, sliced, canned	#10 cn	1.730	0.578
Applesauce, instant	#2 1/2 cn	Applesauce, canned	#303 cn	6.750	0.148
Applesauce, instant	#2 1/2 cn	Applesauce, canned	#10 cn	1.000	1.000
Bacon, sliced, precooked, cn	22 oz cn	Bacon, slab, chilled/fzn	lb	2.000	0.500
Bacon, sliced, precooked, fzn	lb	Bacon, slab, frozen	lb	2.500	0.400
Beans, green, dehydrated	#10 cn	Beans, green, canned	#303 cn	13.034	0.077
Beans, green, dehydrated	#10 cn	Beans, green, canned	#10 cn	2.000	0.500
Beef, corned, canned	6 lb cn	Beef, corned, chilled/fzn	lb	9.960	0.100
Beef liver, sliced, frozen	lb	Beef liver, whole, frozen	lb	1.000	1.000
Beef chunks w/natural juices	29 oz cn	Beef, diced, frozen	lb	1.880	0.532
Cabbage, raw, dehydrated	#2 1/2 cn	Cabbage, fresh	lb	1.880	0.532
Cabbage, raw, dehydrated	#10 cn	Cabbage, fresh	lb	7.500	0.133
Cheese, cottage, dehydrated	#10 cn	Cheese, cottage, fresh	lb	5.990	0.166
Cheese, processed, American, dehydrated	#10 cn	Cheese, cheddar, processed	lb	7.500	0.133
Chicken, boned, canned	29 oz cn	Chicken, whole, RTC, fzn	lb	4.500	0.222
Chicken, cut-up, frozen	lb	Chicken, whole, RTC, fzn	lb	1.300	0.769
Chili con carne w/o beans, cn	6 3/4 lb	Beef, ground, frozen	lb	6.010	0.166
Coffee, freeze dried, instant	lb	Coffee, roasted, ground	lb	5.000	0.200
Egg mix, dehydrated	#3 cyl cn	Eggs, fresh, in-shell	dz	3.460	0.289
Egg whites, frozen	lb	Eggs, fresh, in-shell	dz	1.560	0.641
Eggs, whole, shelled, frozen	lb	Eggs, fresh, in-shell	dz	0.830	1.205
Garlic, dehydrated	2 oz cn	Garlic, dry	lb	0.630	1,587
Ham, canned, chunks	29 oz cn	Ham, boneless, cn/fzn	lb	1.810	0.552
Hamburgers, w/o gravy, canned	12 oz cn	Beef, ground, frozen	lb	0.750	1.330
Hamburgers, w/o gravy, canned	12 oz cn	Beef patties, frozen	lb	0.937	1.066
Horseradish, dehydrated	2 1/2 oz bt	Horseradish, prepared	gl	0.149	6.720

Net storage cube for determining the load factor would be 150 cubic feet. The modular load cube for freeze and dry given in the load tables (Appendix A) is used in the formula to compute the load factor. Once the load factor is determined, the modular load is scaled up or down based on this factor. Exhibit V is an example of computing modular load requirements for a particular ship.

There is a possible alternative to using net storage cube if there are on-hand inventory balances. Gross cube can be reduced by the allowance for physical constraints and proper storage without regard for on-hand balances of modular load items. Only the cubic feet taken up by the non-modular load items need be subtracted, which could be done using the balances on the inventory cards. The resulting load factor can then be used to scale the modular load quantities. Balances on hand for each modular item would then be subtracted from each quantity determined by the load factor. This method would be more convenient when stocks of non-modular load items are low. By accounting for on-hand balances of modular items, the resulting endurance load would be better balanced.

The modular load, as initially developed, does little to improve on the load planning guidance detailed in Chapter III. Except for consolidation of the MLSF support items, the actual computation of requirements is as time consuming as planning normal endurance loads. Additional mechanisms or tools were considered essential to actually enhance load planning capabilities using a modular endurance load. One mechanism is to develop modular endurance loads based on incremental available storage. Pre-planned loads based on varying amounts of available

EXHIBIT V

AVAILABLE STORAGE SPACE (CUBIC FEET):

FREEZE	DRY
150 cu. ft.	400 cu. ft.

ENDURANCE LOAD CUBE:

FREEZE	DRY
114 cu. ft.	324 cu. ft.

STORAGE FACTOR:

FREEZE	DRY
$\frac{150}{114} = 1.32$	$\frac{400}{324} = 1.23$

Each item in the modular load (freeze and dry) would be scaled up by 1.32 and 1.23 respectively.

EXAMPLE:

BEEF, oven roast

500 (load quantity) X 1.32 (freeze load factor) =

660 lbs (load requirement)

storage space would be developed in a table format. The tables might represent endurance load quantities for each additional 40 cubic feet of storage space (approximately 1 pallet load). For example, a dry subsistence load table might start at 200 cubic feet, then have succeeding sections for 240 cubic feet, 280 cubic feet and so on up to 520. Under each section would be listed the quantities of dry items to load for that amount of available storage space. Similar tables for freeze items could be developed. These load tables would be promulgated to both fleet and shore activities for use in emergency loading. In an emergency, a ship would determine the approximate amount of available freeze and dry space, select the tables corresponding to that amount of freeze and dry space and notify the resupply activity of the emergency, the amount of available space, and the correct tables and sections to issue from. The issuing activity could then breakout the load for delivery to the ship on arrival. This approach reduces load computations to a minimum and eliminates the need to transmit a lengthy requirements message from the ship to the resupply activity. A comparable load plan has been developed for use by Atlantic Fleet MLSF ships [Ref. 7]. In the Atlantic Fleet tables, CARGO subsistence items are scaled for several different storage constraints and the MLSF ship notifies the resupply activity of the appropriate table to use for breaking out material.

Another alternative would be to utilize a microcomputer, mini-computer, programmable calculator or even word processing equipment. Each is gaining increased acceptance in the fleet. To display the advantages of this approach, a simple program was developed for the Texas Instruments Programmable Calculator (TI-59).

The TI-59 program is designed to reduce the calculation of load requirements to a minimum. The load planner inputs the net storage cube for freeze or dry subsistence and the program determines the load factor, scales the modular load up or down as required and sequentially prints out the load quantities. Two options are available in determining load requirements; one considers on-hand balances of modular items and the other does not. If the on-hand balances of individual items are not considered, the load planner inputs net storage cube based on gross cube less obstructions, storage considerations and an estimate of the cubic feet of storage space currently used by material on board. The program calculates and prints out load requirements without stopping for input of on-hand balances of modular items. If on-hand balances of individual items are to be considered, the load planner must use an estimate of net storage cube that is not adjusted for on-hand inventories of modular items. This figure would be gross cube less allowances for physical obstructions, aisles and proper storage, and an estimate of the cube used by non-modular items on board. Using this option, the load planner inputs balance on hand for each item and the program calculates and prints the load requirements adjusted for the on-hand inventory. The modular load data for freeze and dry subsistence are on separate magnetic card so the program must be run once for each commodity using the appropriate net storage cube. A similar program could be written for a microcomputer, minicomputer or a comparable programmable calculator. One of the weaknesses of the TI-59 is the limited amount of data storage (100 registers). This limits additional data that could be used in the program, such as case

quantities, which could further enhance load computations. Use of a larger capacity machine would easily overcome this obstacle. Additional program details are in Appendix B.

B. DISCUSSION

While more sophisticated algorithms that could be used for this problem exist in the literature of operations research, this particular approach has the advantages of ease of application by inexperienced personnel and ease of adaptation to a variety of ship types. A typical scenario in which it would be useful might begin with a message received by a surface task group enroute to Subic Bay. The message orders the group to enter Subic Bay for 12 hours maximum and then to proceed to the Sea of Japan for special operations. The duration of the operations is unknown. Subsistence inventories, as well as other supplies, are critically low because a scheduled underway replenishment has just been cancelled. In this situation, using the preplanned endurance tables discussed above, each ship in the task group would estaimte available subsistence storage cube, select the appropriate endurance load table and notify the resupply activity by message of the emergency resupply and the appropriate table to use in breaking out material. Alternatively, if each ship had a program comparable to the TI-59 program discussed above, running the program would produce the desired subsistence load. In either case, the task group commander could be assured that, after emergency resupply, each ship will be mission ready with maximum subsistence endurance.

The use of modular endurance loads for contingency operations can have significant impact on ship's operations both in port and at sea.

By using the modular load quantities, requirements preparation time is reduced, which, in turn, improves the speed of requirements submission to the resupply activity. In fact, if endurance load tables as discussed above are held by the resupply activity, rather than send a complete list of requirements, the requisitioning ship need only indicate the appropriate table to use for the load. The resupply activity can break out material based on the quantities listed in the tables. This is one advantage endurance load tables have over the TI-59 or other programs. Load quantities may be more accurately determined using a load program but the quantities determined for each item must be transmitted to the resupply activity. In either case, the fact that the modular load is more efficient than a normal operating load means that more endurance can be loaded in a shorter amount of time. In part, this reduces loading time and reduces the demands on shore support equipment. At sea, reduced transfer time means a more rapid return to primary mission operations.

This Chapter has discussed the development of a modular load plan for endurance loading subsistence in an emergency. Some of the benefits of this system have been outlined. In the next Chapter, this proposed system will be evaluated against the existing system in a cost-benefit analysis.

V. COMPARISON OF LOAD PLANS

A. METHODOLOGY

Two alternative subsistence load plans were compared to evaluate the significance of different load plans on ship endurance. One load plan was based on a "normal" subsistence load with an endurance base and normal operating items included in the load. This "normal" load was designed to be representative of a load that would be developed using load building guidance as discussed in Chapter III. The second load plan was developed strictly as an endurance load. The modular load discussed in Chapter IV was the basis for this endurance load.

Using the normal operating load plan, a ship would order and store quantities of subsistence items based on usage data and available storage space. Endurance levels would only become a consideration up to the minimum fleet requirement. Normal operating items, such as beef round or corn-on-the-cob would round out the load. In building the normal operating load, only those items available from subsistence carrying MLSF ships (AFS, AOE, AOR) were included. This was done to simulate a deployed scenario in which there would be a high probability of replenishment from the MLSF. Further, this approach allows evaluation of the impact each load might have on underway replenishment (UNREP).

The endurance load plan was developed solely from the modular load items in Appendix A. Quantities ordered and stored using this plan were

based on available storage space. Although Appendix A lists substitutes for some subsistence items, none were used in this analysis.

Cost-benefit analysis techniques were used to evaluate the two alternative load plans. The cost-benefit approach allows key factors to be quantified and provides a rational basis for evaluating the differences between the two load plans and the significance of each on ship endurance.

1. Data Base

A standard support base of 9,000 mandays (90 days support for 100 men) was used to allow comparison of the modular endurance load with a normal operating load. To simulate a normal operating load, the recommended quantities of subsistence for 9,000 mandays support, as listed in CARGO [Ref. 2], were used. Subsistence items listed in CARGO are based on fleet demand and therefore, were selected as representative of a normal operating load. Quantities for the 45 day modular load were doubled to equal 9,000 mandays support.

Several subsistence factors were held constant or excluded from the analysis to facilitate comparison of the two load plans in terms of basic endurance. Seasonal and holiday items were excluded from both loads as non-essential to basic endurance requirements. This would include whole turkeys, pumpkin and other items listed in CARGO as seasonal or for holiday use only. The impact of these and other subsistence items on crew morale will be discussed later. Additionally, of the three storage categories of subsistence (chill, freeze and dry), only data for freeze and dry items were included in the analysis. As noted in Chapter IV, the two chill items in the endurance load are

generally not space constrained and, therefore, were not evaluated for endurance effectiveness. Other chill storage items, such as fresh fruits, vegetables and some dairy products have relatively short shelf lives. Because of this fact, these items are not considered as part of the endurance question. These items should be resupplied at every available opportunity.

2. Basic Assumptions

In analyzing the alternative load plans, basic assumptions were made with regard to strategic planning, quality of subsistence support, ships' missions and a standard consumption rate.

First, given a contingency scenario, it is assumed that fleet endurance would become a significant planning factor for fleet commanders. Under normal operating conditions, ships are expected to be capable of various missions based on established endurance levels. Minimum endurance levels for subsistence, fuel and ammunition are based in part on projected operational requirements and scheduled resupply opportunities. However, given a greater degree of uncertainty, where mission requirements and resupply opportunities are not as predictable, endurance capability would logically assume greater significance. For this analysis, the endurance requirements for fuel, ammunition, maintenance and other mission factors have been held constant. The impact of subsistence endurance in relation to these factors will be discussed at the end of the analysis.

Second, minimum quality levels were assumed for food service operations. Carrying the matter to extremes, the requirement to sustain fleet operations could be accomplished with little regard for personnel

requirements other than bare minimum subsistence. Prior to the twentieth century, sailors spent weeks and even months subsisting on salt pork, hard tack or other similar foods. Such fare is obviously not acceptable today. As noted in Chapter IV, subsistence load plans must meet basic menu planning criteria. Alternative load plans in the analysis conform to these criteria.

Third, three ship types (CVA, DDG, LST) were selected as representative of all combatants. These three types were selected as representative of the broad spectrum of crew sizes and designed endurance capability among combatants. Rates of consumption were considered constant for all ship types.

Other assumptions pertaining to specific elements of the analysis are contained within each analysis subsection.

B. ANALYSIS OF EFFECTIVENESS

Storage efficiency was used as one measure of the endurance capability for each alternative load. Less storage space required per day of endurance means more endurance can be loaded. The cubic feet of storage required for each subsistence load (normal operating and modular endurance) was divided by the number of days' support in each load, in this case 90 days (9,000 mandays). The number resulting from this computation is the number of cubic feet of storage required for each day of support. The following formula applies to this computation:

$$\begin{array}{c}\text{Storage Efficiency} \\ \text{(cubic feet/day)}\end{array} = \frac{\text{TOTAL LOAD CUBE}}{\text{90 days}}$$

As noted above, chill subsistence storage requirements were excluded from the analysis.

The storage efficiency of each alternative load is presented in Exhibit VI. From these data it can be seen that a 90 day (9,000 mandays) load using the normal operating plan requires 11.96 cubic feet of storage per day. A 90 day modular endurance load requires only 9.73 cubic feet of storage per day. The modular load represents a savings of 18.6 % or 200 cubic feet over 90 days. Presumably an additional 20.6 days endurance could be stored in the space saved by using the modular load plan. It should be noted, however, that these data represent total storage space requirements for freeze and dry subsistence items combined. Because of differences in storage characteristics between freeze and dry items, the storage efficiency of dry and freeze commodities were computed separately. Exhibit VII presents these data. Exhibit VII shows that the most significant gains in storage efficiency between the alternative plans are in freeze items. Modular endurance load freeze items require 37% less storage than a normal operating load while modular dry items require 9.2% less storage space. Caution should be used, however, in attempting to analyze the significance between dry and freeze storage efficiency. Initially, the ability to load a greater number of days endurance in freeze items appears to be a plus for modular endurance load plans. In fact, the efficiency of freeze storage in the modular load _is_ favorable, however, storage efficiency in freeze items can be accomplished only through some trade-offs with dry items. Because the modular endurance load plan is based on more austere feeding than normal, a number of items that would normally be carried as freeze have been replaced in the modular load by dry items. For example, frozen vegetables have been replaced by similar canned or

EXHIBIT VI

EFFECTIVENESS ANALYSIS

BENEFIT	MEASURE	ALT I NORMAL LOAD	ALT II MODULAR LOAD
STORAGE EFFICIENCY	CU.FT. STOW/DAY*	$\frac{1076}{90} = 11.96$	$\frac{876}{90} = 9.73$

* The required cubic feet of storage per day of endurance

EXHIBIT VII

EFFECTIVENESS ANALYSIS

BENEFIT	MEASURE	ALT I NORMAL LOAD	ALT II MODULAR LOAD
STORAGE EFFICIENCY BY STORAGE CATEGORY	CU.FT. STOW/DAY*	FREEZE: $\frac{362}{90} = 4.02$	$\frac{228}{90} = 2.53$
		DRY: $\frac{714}{90} = 7.93$	$\frac{648}{90} = 7.20$

* The required cubic feet of storage per day of endurance

ration-dense items, and the quantity of canned meats has been increased. These trade-offs allow more basic endurance freeze items to be loaded. Without the dry items, however, the capability for balanced menu planning does not exist. This requirement for menu balance leads to the question of maintaining the balance between freeze and dry items when loading under the modular load plan.

In the normal operating load, if it is built properly, the balance betwen freeze and dry items is maintained because of demand factors used to develop inventory high and low limits. The modular load has no such flexible factors for maintaining balance. If the load factors used to determine the multiples of modular items are the same for freeze and dry, then balance is not a problem. The integrity of the basic 4,500 manday modular load is maintained. As noted in Chapter IV, the chances of freeze and dry load factors being equal is small. One possible solution to this problem is to use the smaller load factor (freeze or dry). If the load factor for dry were 2.0 and the factor for freeze were 4.0, then the modular load would be scaled up by a factor of two. The balance of the freeze space could be used to load any additional endurance items or normal operating items deemed necessary for better menu variety or morale.

The actual benefits of using a modular endurance load will vary with each class of ship due to differences in designed storage capacity and manning levels. The actual endurance of a ship class is a function of storage space and the number of personnel on board. To quantify the benefits of each alternative load plan for various ship types, an estimate of the actual number of days' endurance obtainable from each

alternative was derived for three ship types (CVA, DDG, LST). The following formulas were used:

$$\text{STOW FACTOR} = \frac{\text{NET STORAGE SPACE}}{\text{90 DAY LOAD CUBE}}$$

$$\text{MANDAYS SUPPORT} = \text{STOW FACTOR} \times 9{,}000$$

$$\text{DAYS ENDURANCE} = \frac{\text{MANDAYS SUPPORT}}{\text{NUMBER OF MEN ON BOARD}}$$

Net storage space used in the formula for stow factor was derived by taking 55% of the gross cube in freeze and dry storage for each ship type. Fifty-five percent represents the approximate amount of storage space available after allowing for obstructions, aisles, overhead clearance and proper storage techniques. It is recognized that this percentage can vary between ships, however, 55% is considered optimum for storage planning. Gross cube data are estimates for the subsistence storage space in a typical CVA, DDG and LST. These data will vary based on specific classes and design modifications, however, the relative difference between available space in the three ship types remains approximately the same. For number of days' endurance computations, the number of personnel on board each of the three ship types was based on designed compliment as listed in Jane's Fighting Ships [Ref. 6]. More precise data are available, however, due to classification they were not used in this analysis. The results of the analysis are not materially affected.

The number of days' endurance derived from the above formulas for both the normal and modular load are presented in Exhibit VIII. As might be expected from the greater storage efficiency of the modular freeze load, as shown in Exhibit VII, the greatest endurance gains

EXHIBIT VIII

SHIP TYPE	AVAILABLE STORAGE (NET)	÷ 90 DAY CUBE	= STOW FACTOR (DAYS)	X 9000 = MANDAYS	÷ # MEN ONBOARD	= DAYS ENDURANCE
CVA	Dry - 35,000	ND 714	49	441,000	5,000	90
		MD 668	52	468,000		94
	Freeze - 12,000	NF 362	33	297,000		61
		MF 228	53	477,000		97
DDG	Dry - 1,200	ND 714	1.7	15,300	355	43
		MD 668	1.8	16,200		46
	Freeze - 600	NF 362	1.7	15,300		43
		MF 228	2.6	23,400		66
LST	Dry - 2,000	ND 714	2.8	25,200	400	63
		MD 668	3.0	27,000		68
	Freeze - 800	NF 362	2.2	19,800		50
		MF 228	3,5	31,500		79

KEY:

ND - Normal load dry
MD - Modular load dry
NF - Normal load freeze
MF - Modular load freeze

between alternative loads occur in freeze. However, gains in freeze endurance alone may not be relevant when consideration is given to a balanced load. As noted above, in developing a modular endurance load, trade-offs between freeze and dry items must occur to avoid sacrificing menu planning capability for endurance. Thus, dry storage efficiency shows less of a gain between a normal and modular load because of the increases in canned products and ration-dense foods. As suggested earlier, one alternative to maintaining the balance between freeze and dry in the modular load is to use the smaller or limiting load factor in determining both freeze and dry load quantities. Applying this approach to Exhibit VIII, the endurance gains are more modest. Dry subsistence is the limiting factor in each of the three cases, therefore, when loading multiples of the modular load, there will be storage capacity remaining in freeze spaces. Freeze spaces would have to be topped off with additional items to ensure that all available storage space is utilized. If the difference between freeze and dry stow factors is significant and if mechanically feasible, one freeze space could be converted to dry storage. This could allow storage of additional multiples of the modular load. Also, given sufficient time and material assets, portable storage containers, such as CONEX containers might be installed to allow additional dry items to be loaded. This alternative must be carefully considered to avoid limiting the primary mission capabilities of a combatant. Portable storage facilities may not be compatible with the ship's design.

Exhibit VIII also shows that some smaller ships may not be capable of meeting minimal prescribed endurance levels using either load alternative

with proper storage practices. This problem is usually solved by disregarding optimum storage practices and fully loading all available storage space. This frequently has an adverse affect on refrigeration machinery and reduces the shelf life of both dry and freeze subsistence items due to overcrowding, poor ventilation and poor stock rotation.

C. ANALYSIS OF COSTS

There are three relevant costs identifiable to each of the load plans. The first is an opportunity cost based on resupply frequency. The fewer times a ship must resupply over a given period, the more time is available to engage in its primary mission. The second cost is the time actually required to be spent engaged in resupply. This cost, measured in alongside time, not only impacts on primary mission time but also increases the vulnerability of the ship to attack. The third cost is not quantifiable but may have the largest impact on mission capability. The cost is morale. Although balanced menu planning is built into each of the alternative loads, there are still only a limited variety of foods and meal combinations. The more austere the load, even though capable of supporting basic menu planning, the greater the chance for possible crew dissatisfaction due to unpopular food items or meal monotony.

Other costs, such as material and labor, are sunk costs and not relevant to the analysis. Each of the relevant costs described above will be discussed in turn.

1. Cost of Endurance

Chapter I identified the magnitude of the investment in manhours, time and equipment associated with resupply operations. The

fewer times a ship is required to make this investment over an operating period the better. Since endurance capability varies for each class of ship, the number of times resupply is required will also vary. The following formula was derived to evaluate the cost of resupply for various ship types using each load alternative:

$$\text{RESUPPLY MULTIPLE} = \frac{(\text{180 DAYS}) \times (\text{CREW SIZE})}{\text{ENDURANCE}}$$

The 180 days represents the number of days a ship might be involved in any particular operating cycle. This factor times the crew size is an estimate of the number of mandays support that would be required over the cycle. The endurance factor is the lesser of freeze or dry endurance available under each alternative (in man-days). This accounts for the storage efficiency constraints of either freeze or dry items as discussed in the effectiveness analysis above. The resupply multiples derived from the above formula are relative measures of the cost of using each alternative for various ships.

Resupply multiples for the three ship types (CVA, DDG, LST) are presented in Exhibit IX. Although these resupply multiples do not represent the actual number of replenishments which can be expected to occur, it is reasonable to suppose that the actual number for each ship type will be proportional to the resupply multiple. For example, over a given period a DDG might require resupply twice as often as a CVA or LST under either alternative. Thus, a comparison can be made between the percentage differences of resupply multiples for each alternative within each ship type. From Exhibit IX it is determined that use of a modular endurance load could result in 34% fewer resupplies

EXHIBIT IX

COST ANALYSIS

(RESUPPLY MULTIPLE)

SHIP TYPE	180 DAYS	X	CREW SIZE	÷	ENDURANCE*	= RESUPPLY MULTIPLE
CVA	180	X	5000	÷	61 (normal) 94 (modular)	= 2.9 = 1.9
DDG	180	X	355	÷	43 (normal) 46 (modular)	= 4.2 = 3.9
LST	180	X	400	÷	50 (normal) 68 (modular)	= 3.6 = 2.6

* Endurance is the minimum of either freeze or dry under each alternative load.

for a CVA. The savings for DDG and LST ship types are 7% and 28% respectively. The ship with the highest resupply multiple under either alternative, DDG in this case, reduces resupply cost the least by using the modular load. This approach obviously overlooks bimonthly or monthly replenishment schedules necessary for resupply of materials in addition to subsistence, however, it does give a picture of the relative impact each alternative has on resupply costs.

2. Cost of Resupply Time

The time required to accomplish resupply for a given level of endurance was calculated for each alternative load plan. This time is considered as another cost associated with each plan. Since actual resupply time will vary based on resupply requirements and the method of resupply, a standard 90 day load was used for each alternative. Underway replenishment (UNREP) was fixed as the resupply method. UNREP vice in port resupply was used based on availability of data. Significant time costs are also associated with in port resupply, however, no standard reports on these costs are prepared. The use of UNREP as the resupply method also allows some evaluation of the impact each load alternative might have on the resupply ships (MLSF ships).

The actual cost associated with resupply is measured by the time required to transfer an equivalent amount of support under each alternative. In this case, the time required to transfer 90 days endurance using a normal operating load was compared with the time required using a modular endurance load. Transfer rates for two ship types were developed from historical UNREP data and the author's experience. Transfer rates, in short tons (S/T) per hour, were used in conjunction with the following formulas to compute transfer time.

$$\text{TRANSFER TIME} = \frac{\text{SHORT TONS (S/T) PER 90 DAYS ENDURANCE(9,000 mandays)}}{\text{TRANSFER RATE BY SHIP TYPE (S/T per hour)}} \times \frac{\text{CREW SIZE}}{100}$$

This formula first computes the transfer rate for 90 days endurance (in short tons) for each alternative load and for each of the ship types. The transfer rate is then multiplied by the number of 100 man multiples on board each ship. Since the loads under each alternative are based on support for 100 men for 90 days, a ship with 500 men would be required to transfer the equivalent of one 9,000 manday load five times. The total transfer time would, therefore, take five times as long as a single 9,000 manday load. No time allowance is given for break outs or staging on the resupply ship or delays due to equipment failure or other problems. The transfer rates assume the use of optimal transfer modes, that is connected replenishment (CONREP), vertical replenishment (VERTREP) or a combination of both modes to larger ships (CVA).

The transfer times for a CVA and a DDG are computed in Exhibit X. Transferring 90 days endurance to a CVA using a normal operating load (Alternative I) requires approximately 4.6 hours. The same endurance could be transferred in 3.8 hours using a modular endurance load, a 17.4% savings in time. The time savings to a DDG is 15.7%.

The impact of cost savings to any ship is difficult to assess given the number of variables held constant in the above calculations. Reduced time alongside or at VERTREP stations allows a more rapid return to flight operations, Antisubmarine Warfare (ASW) or other primary mission tasks. Reduced resupply time also means a shorter period of

EXHIBIT X

COST ANALYSIS

SHIP TYPE	S/T ÷ TXFR RATE		= HRS	X # MEN / 100	= TRANSFER TIME ALT I (NOR)	TRANSFER TIME ALT II (MOD)
CVA	N - 17.2	185	.093	50.00	4.7 HRS	
	M - 14.2	185	.077	50.00		3.8 HRS
DDG	N - 17.2	34	.506	3.55	1.8 HRS	
	M - 14.2	34	.418	3.55		1.5 HRS

KEY: S/T - Short tons per 9,000 manday load
TXFR RATE - Transfer rate in short tons per hour
N - Normal load
M - Modular load

vulnerability to attack. The actual time savings for any given resupply operation, however, might easily be offset by delays due to weather, equipment malfunctions or delays on the resupply ship. Additionally, the need to maintain UNREP skills might require additional time alongside. It would appear that the advantages of a modular endurance load in terms of UNREP time costs would be most significant in an emergency where time was the critical factor. In an emergency, the modular endurance load would require less time for the resupply ship to break out and stage, meaning faster UNREP preparation, and less time in actual transfer.

3. Cost of Morale

Perhaps the most difficult cost to assess for each alternative is the cost of morale. Despite the balanced menu capability of both load plans, there must be some evaluation of the differences between alternatives and the impact each might have on morale. In this analysis, the normal operating load contains 75 additional subsistence items not carried in the modular endurance load. It is reasonable to assume that the greater menu variety using the normal load might have a more positive impact on morale. This could be considered a penalty cost in using the modular load. Since the mocular load is designed to maximize endurance in response to an emergency, some assessment would have to be made on the impact reduced menu variety might have over time. Because of the importance of crew morale to mission readiness, the decision to use the modular load might best be made by the task group commander. The potential for adverse impact on crew morale might outweigh the endurance and time advantages of using the modular load.

E. EVALUATION OF ALTERNATIVES

1. Quantifiable Factors

The principle advantage of the modular endurance load over the normal operating load, in terms of benefits, can be seen from Exhibit VI. The capability of storing the same number of days' endurance (90) in less space has obvious advantages. The more efficient storage space is utilized, the more material that can be stored. The capability to improve storage and thereby increase ships' capacity is beneficial to all classes of ships; however, some would benefit more than others. As Exhibit VIII shows, if available storage space is large relative to the number of personnel to be supported, then effective use of storage space is of less concern. A CVA is designed with greater endurance capability than a DDG. An LST has additional storage to allow for support of embarked Marines. Both the CVA and LST can meet their prescribed endurance levels without difficulty. In a contingency, however, it might be just as important for ships like a CVA or LST as for the DDG to load for maximum endurance. In addition to increasing their own endurance, they might find themselves resupplying smaller ships because of reduced MLSF assets. This might be particularly true for a CVA which is escorted by ships with lesser endurance capability. Using a modular endurance load, a CVA could totally support the additional 355 men on a DDG and endurance for the CVA would only be reduced by 7 days in dry items and 6 days in freeze items.

The cost advantages of a modular load over a normal load can be seen in Exhibits IX and X. By reducing the frequency of resupply and the actual time spent conducting resupply thousands of

manhours can be saved and primary missions could have fewer interruptions. Less frequent UNREPS and reduced alongside time mean less vulnerability to attack. Additionally, the reduced number of short tons (14.2 vice 17.2) per 9,000 manday load transferred during UNREP is an added savings to the MLSF. Fewer manhours are required on the MLSF to break out, stage and transfer material.

Another view of the advantages of a modular load over a normal load is in terms of the constraining factors. The resupply multiples (Exhibit IX) are based on the minimum endurance constraint for either freeze or dry. By using the modular load, the minimum endurance increases by 54% for a CVA, 36% for an LST, and 7% for a DDG. The increase is not as great for the DDG, however it still represents an opportunity to improve endurance and the quality of support. Since the minimum endurance level is increased, the additional space available to the non-limiting factor (freeze of dry) can be used to load additional menu support items, items that will enhance morale.

2. <u>Non-Quantifiable Factors</u>

As discussed earlier, the impact of each load plan on crew morale is difficult to assess. The loss of a number of menu support items, in this case 75, must have some negative impact over a given period. Even if menu monotony is minimal, the inconveniences that might be associated with a modular endurance load could possibly affect food service operations. For example, meal preparation time might increase due to the need to make a number of recipes from scratch rather than using prepared items. Also, food service personnel might lack the expertise needed to prepare ration-dense foods. If

improperly prepared, such items as dehydrated cottage cheese or applesauce can be less palatable than their fresh or frozen counterparts.

3. Sensitivity Testing

In testing both alternatives for sensitivity, it was found that because of the initial differences between the normal and modular load, the relationship between the two alternatives remains constant. For example, the measure of storage efficiency (Exhibits VI and VII) is the basis for determining the endurance attainable from each load. The same proportional relationship between normal and modular load efficiency remains even as the size of the ship and endurance capabilities change. There is, however, some evidence to suggest that the benefits of a modular endurance load have more impact on improved endurance for a small ship than a large ship. In Exhibit VIII the number of days endurance using each alternative shows that a DDG has significantly less initial endurance than either a CVA or LST. Use of a modular endurance load allows the DDG to increase endurance above a minimum of 45 days. The CVA and LST are initially above minimum requirements so the impact is not as great.

The fact that the minimum endurance level between freeze and dry is used for load planning has an impact on the effectiveness of using either alternative. As noted above, the minimum constraint for a CVA goes from 61 days using a normal load to 94 days using a modular load. This is a significant increase in endurance capability and allows the CVA more flexibility in loading additional menu support items. For the DDG the increase in minimum endurance is not as great (43 to 46 days). The increase in the non-limiting factor, however, is

significant. As Exhibit VIII shows, the non-limiting factor for the DDG is freeze with 66 days endurance. This means that the additional space available in freeze when the load is computed based on the dry constraint can be used for loading additional menu support items. For a small ship, the ability to achieve increased endurance and enhance menu planning is significant.

VI. CONCLUSIONS AND RECOMMENDATIONS

The modular endurance load plan presented in Chapter IV of this thesis appears to have significant advantages over load planning guidance now being used by U.S. Navy ships. The modular load can be developed in a minimum amount of time with little expertise, providing maximum subsistence endurance in a limited amount of storage space. Because of the storage efficiency of the modular endurance load, more endurance can be resupplied in a shorter period of time and resupply is required with less frequency. For a combatant, this means being assured of operational readiness in the subsistence area while devoting less time to resupply operations. For all classes of Navy ships, use of the modular endurance load in an emergency can aid mission readiness.

The significant disadvantage of the modular endurance load is its limited variety of subsistence items. Because it is designed for more austere feeding, it has fewer line items to support menu planning. This fact could, over a longer period of operations, detract from crew morale and subsequently mission capability of a ship. For this reason it is not recommended that the modular endurance load be used for any situation other than an emergency.

In view of the significant advantages of using a modular endurance load for emergency ship loading, it is recommended that the Naval Supply Systems Command give consideration to promulgating contingency load planning guidance similar to the modular load concept proposed in this thesis. Contingency load planning guidance could be incorporated

in Food Service Management (NAVSUP P-486) using preplanned endurance load tables. Lack of standardized data processing equipment in Navy ships would preclude detailed endurance load guidance using a program similar to the one developed herein. However, general programming guidance could be included which would allow individual ships to adapt their own programs for endurance loading. Since much of the modular endurance load conforms to basic menu planning and endurance loading guidance currently presented in NAVSUP P-486, it is anticipated that the cost of implementing these supplemental subsistence loading guidelines would be minimal.

APPENDIX A: MODULAR ENDURANCE LOAD

45 DAY SUBSISTENCE ENDURANCE FOR 100 MEN

SUMMARY DATA:

	LINE ITEMS	STORAGE CUBE (NET)
FREEZE	25	114 cubic feet
DRY	94	324 cubic feet
CHILL	2	8 cubic feet

- -

FREEZE

DESCRIPTION	UNIT OF ISSUE	TOTAL QUANTITY	CARGO NUMBER	SUBSTITUTES
MEAT, POULTRY AND FISH				
BEEF, OVEN ROAST	lb	500	Q17	
BEEF, POT ROAST	lb	400	Q19	
BEEF, braising steak, Swiss	lb	371	Q24	
BEEF for stewing, diced	lb	121	Q28	
BEEF, patty mix, bulk	lb	600	Q31	
BEEF, patties	lb	150	Q33	Q31
BEEF Liver	lb	75	Q42	
BOLOGNA	lb	40	Q49	
CHICKEN, cut-up	lb	200	Q58	
FISH PORTIONS, breaded	lb	75	Q84	Q83
FRANKFURTERS	lb	75	Q95	
HAM, cooked, boneless	lb	90	RO4	
PICKLE and PIMIENTO Loaf	lb	40	R18	
PORK, diced	lb	44	R44	
PORK, loin	lb	78	R51	

MEAT, POULTRY AND FISH Continued

DESCRIPTION	UNIT OF ISSUE	TOTAL QUANTITY	CARGO NUMBER	SUBSTITUTES
PORK, chops	lb	175	R53	
PORK SAUSAGE, bulk	lb	120	R64	R65
SALAMI, cooked	lb	45	R75	
TURKEY, boneless	lb	160	R89	

DAIRY FOODS AND EGGS

DESCRIPTION	UNIT OF ISSUE	TOTAL QUANTITY	CARGO NUMBER	SUBSTITUTES
BUTTER, prints	lb	138	SO1	
BUTTER, patties ready-to-serve	lb	168	SO6	
EGGS, whole	lb	120	S14	

FRUITS AND VEGETABLES

DESCRIPTION	UNIT OF ISSUE	TOTAL QUANTITY	CARGO NUMBER	SUBSTITUTES
BROCCOLI	lb	100	S66	S52, S70, S92, T48
CAULIFLOWER	lb	100	S76	S52, S70, S92, T48
VEGETABLES, mixed	lb	200	T52	S52, S70, S92, T48

DRY (NON-PERISHABLE)

DRY MEAT, POULTRY AND FISH

DESCRIPTION	UNIT OF ISSUE	TOTAL QUANTITY	CARGO NUMBER	SUBSTITUTES
BACON, sliced precooked	cn	87	AO2	
BEEF CHUNKS	cn	32	AO6	
CHICKEN, boned	cn	40	AO8	
LUNCHEON MEAT	cn	12	A16	
SALMON, pink	cn	40	A21	
TUNA, 4 lb	cn	24	A32	

DESCRIPTION	UNIT OF ISSUE	TOTAL QUANTITY	CARGO NUMBER	SUBSTITUTES
DRY DAIRY FOODS and EGGS				
CHEESE, Cottage	cn	8	A52	
CHEESE, Parmesan and Romano	co	5	A56	
EGG MIX, dehyd.	cn	69	A60	
ICE MILK - MILK SHAKE	cn	14	A63	A68
MILK, nonfat, dry (beverage)	cn	95	A72	
MILK, nonfat, dry (cooking)	cn	30	A76	
DRY FRUITS and VEGETABLES				
APPLESAUCE	cn	72	B10	
BEANS, green, dehyd.	cn	64	B29	
BEANS, kidney, dry	lb	48	B35	
BEAN SPROUTS	cn	5	B62	
BEETS	cn	40	B66	
CARROTS	cn	24	B80	
CORN, cream style	cn	16	CO2	
CORN, whole grain	cn	21	CO6	
CRANBERRY SAUCE	cn	7	C14	
FRUIT COCKTAIL	cn	24	C26	
GRAPEFRUIT	cn	100	C30	
JUICE, APPLE	cn	36	C32	C38, C40, C65
JUICE, GRAPE, inst.	cn	16	C37	
JUICE, ORANGE	cn	48	C52	C38, C40, C65

DRY FRUITS
and VEGETABLES Cont.

DESCRIPTION	UNIT OF ISSUE	TOTAL QUANTITY	CARGO NUMBER	SUBSTITUTES
JUICE, PINEAPPLE	cn	36	C58	
JUICE, TOMATO, conc.	cn	73	C61	
MUSHROOMS	cn	20	C73	
ONIONS, dehyd.	cn	120	C82	
PEACHES	cn	36	C93	B18, D30, D34
PEARS	cn	61	C99	B18, D30, D34
PEPPERS, dehyd.	cn	42	D14	
POTATOES, sweet	cn	80	D44	
POTATOES, dehyd., sliced	bg	20	D51	
POTATOES, dehyd., inst.	cn	18	D54	
SAUERKRAUT	cn	8	D68	
SPINACH	cn	8	D72	DO8
TOMATOES	cn	78	D76	

BAKERY AND
CEREAL PRODUCTS

DESCRIPTION	UNIT OF ISSUE	TOTAL QUANTITY	CARGO NUMBER	SUBSTITUTES
CAKEMIX, devils food	cn	14	E22	E12
CAKE MIX, white	cn	14	E31	E12
CAKE MIX, yellow	cn	28	E34	E12
CEREAL, ind., assorted	bx	15	E56	
CEREAL, rolled oats	cn	67	E68	
HOMINY GRITS	co	24	F76	
COOKIE MIX	cn	4	F11	
CORN BREAD MIX	cn	11	F15	

BAKERY AND CEREAL PRODUCTS Cont.

DESCRIPTION	UNIT OF ISSUE	TOTAL QUANTITY	CARGO NUMBER	SUBSTITUTES
CRACKERS, Soda	lb	40	F40	
FLOUR, wheat, bread	bg	35	F54	
NOODLES, egg	lb	8	F92	
RICE, parboiled	lb	60	G13	
SPAGHETTI	lb	68	G19	F82
STARCH, Corn	lb	15	G21	
SUGAR, CONFECTIONERY, AND NUTS				
COCONUT, prepared	cn	4	G78	
SUGAR, brown	bg	24	H17	
SUGAR, granulated	bg	96	H22	
SUGAR, powdered	bg	48	H31	
SYRUP, imit, maple	cn	102	H11	
NUTS, mixed	cn	1	HO1	
JAMS, JELLIES AND PRESERVES				
JAM, strawberry	cn	8	H53	
JELLY, grape	cn	6	H62	
PEANUT BUTTER	cn	19	H72	
SOUPS				
SOUP, dehyd., beef w/noodles	cn	37	J14	
SOUP, dehyd., chicken w/noodles	cn	38	J17	

SOUPS Cont.

DESCRIPTION	UNIT OF ISSUE	TOTAL QUANTITY	CARGO NUMBER	SUBSTITUTES
SOUP, dehyd., tomato - vegetable	cn	37	J29	
SOUP and GRAVY BASE, Beef	cn	14	J53	
SOUP and GRAVY BASE, Chicken	cn	14	J61	

SPECIALTY FOODS

CHILI CON CARNE	cn	8	J70	
CREAM SUBSTITUTE	hd	63	J76	
DESSERT POWDER, cherry	cn	12	J79	J85, J88, J94
DESSERT POWDER, inst., vanilla	cn	8	KO2	
DESSERT POWDER, inst., chocolate	cn	6	KO7	
PIE FILLING, APPLE	cn	30	K33	K35, K41
PIE FILLING, CHERRY	cn	15	K38	K35, K41
TOPPING, dessert	cn	12	K64	

FOOD OILS AND FATS

SALAD OIL	cn	7	K91	
SHORTENING COMPOUND	cn	69	K99	K98 (large ships)

CONDIMENTS

BAKING POWDER	cn	15	MO6	
CATSUP, tomato	cn	3	M23	M21
MUSTARD, prepared	cn	2	N25	
OLIVES, green	jr	28	N31	

CONDIMENTS Cont.

DESCRIPTION	UNIT OF ISSUE	TOTAL QUANTITY	CARGO NUMBER	SUBSTITUTES
OLIVES, ripe	cn	21	N35	
PEPPER, black	cn	3	N46	
PICKLES, dill	cn	5	N59	
PICKLES, mixed, sweet	cn	5	N68	
RELISH, pickle, sweet	cn	2	N76	
SALAD DRESSING	cn	40	N81	
SALT, table	lb	102	N87	
VINEGAR	pg	30	P10	
COFFEE, TEA AND COCOA				
COCOA	cn	18	P20	
COFFEE, roasted, ground	lb	338	P29	P23
TEA, black, bags	bx	16	P31	P38
BEVERAGES				
BEVERAGE BASE, cherry	pg	25	P50	P61, P79

CHILL

DESCRIPTION	UNIT OF ISSUE	TOTAL QUANTITY	CARGO NUMBER	SUBSTITUTES
HAM, CANNED, PULLMAN	lb	226	U15	
CHEESE, cheddar	lb	115	U42	

APPENDIX B

TI-59 LOAD PROGRAM	USER INSTRUCTIONS		
STEP	PROCEDURE	ENTER	PRESS
1	Repartition	10	2nd OP 17
2	Input program note: freeze and dry programs must be run separately.	1 2	Read in card
3	Enter 0 for no inventory or 1 for inventory. note: If inventory is to be considered it must be entered sequentially as the program runs.	0	STO 01
4	Enter available cube data note: If inventory is to be considered enter gross cube less storage constraints (do not subtract cube of material on hand)	cu ft	STO 00
5	Initialize		R/S
6	Input balance on hand note: If inventory is not considered stop at step 5.	qty	R/S

```
000   91  R/S
001   58  FIX
002   02   02
003   43  RCL
004   02   02
005   22  INV
006   49  PRD
007   00   00
008   13   C
009   43  RCL
010   00   00
011   49  PRD
012   04   04
013   00   0
014   32  X:T
015   43  RCL
016   01   01
017   22  INV
018   67   EQ
019   12   B
020   14   D
021   22  INV
022   49  PRD
023   04   04
024   00   0
025   32  X:T
026   43  RCL
027   04   04
028   58  FIX
029   00   00
030   67   EQ
031   11   A
032   42  STO
033   04   04
034   42  STO
035   07   07
036   14   D
037   49  PRD
038   04   04
039   15   E
040   49  PRD
041   07   07
042   43  RCL
043   07   07
044   44  SUM
045   05   05
```

```
046   43  RCL
047   04   04
048   99  PRT
049   58  FIX
050   02   02
051   76  LBL
052   11   A
053   01   1
054   42  STO
055   04   04
056   92  RTN
057   76  LBL
058   12   B
059   91  R/S
060   91  R/S
061   22  INV
062   44  SUM
063   04   04
064   92  RTN
065   76  LBL
066   13   C
067   73  RC*
068   03   03
069   65   x
070   93   .
071   00   0
072   00   0
073   00   0
074   00   0
075   00   0
076   01   1
077   95   =
078   42  STO
079   04   04
080   92  RTN
081   76  LBL
082   14   D
083   73  RC*
084   03   03
085   42  STO
086   09   09
087   43  RCL
088   09   09
089   65   x
090   93   .
091   00   0
```

092	00	0
093	00	0
094	00	0
095	00	0
096	01	1
097	95	=
098	52	EE
099	22	INV
100	52	EE
101	65	X
102	01	1
103	00	0
104	00	0
105	00	0
106	00	0
107	00	0
108	00	0
109	95	=
110	22	INV
111	44	SUM
112	09	09
113	43	RCL
114	09	09
115	92	RTN
116	76	LBL
117	15	E
118	73	RC*
119	06	06
120	01	1
121	44	SUM
122	06	06
123	92	RTN
124	01	1
125	44	SUM
126	03	03
127	00	0
128	32	X:T
129	43	RCL
130	03	03
131	75	-
132	03	3
133	05	5
134	95	=
135	67	EQ
136	91	R/S
137	61	GTO
138	00	00
139	08	08

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114.	02
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0.	04
0.	05
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0.	07
0.	08
0.	09
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400000050.	11
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600000050.	14
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75000050.	19
75000040.	20
90000050.	21
40000060.	22
44000050.	23
78000050.	24
175000050.	25
120000060.	26
45000060.	27
160000060.	28
138000060.	29
168000030.	30
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10000024.	33
200000024.	34
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0.	37
0.	38
0.	39
0.	40
0.	41
0.	42
0.	43
0.	44
0.	45
0.	46
0.	47

0.	48
0.	49
0.87	50
0.87	51
1.29	52
0.87	53
1.17	54
2.36	55
0.52	56
1.25	57
1.85	58
0.31	59
1.13	60
1.25	61
1.67	62
1.25	63
1.25	64
1.25	65
1.27	66
0.	67
1.67	68
1.58	69
1.13	70
1.58	71
1.17	72
1.06	73
1.06	74
1.06	75
0.	76
0.	77
0.	78
0.	79
0.	80
0.	81
0.	82
0.	83
0.	84
0.	85
0.	86
0.	87
0.	88
0.	89
0.	90
0.	91
0.	92
0.	93
0.	94
0.	95
0.	96
0.	97
0.	98
0.	99

```
000  91  R/S
001  58  FIX
002  02   02
003  43  RCL
004  02   02
005  22  INV
006  49  PRD
007  00   00
008  13   C
009  43  RCL
010  00   00
011  49  PRD
012  04   04
013  00   0
014  32  X:T
015  43  RCL
016  01   01
017  22  INV
018  67   EQ
019  12   B
020  14   D
021  22  INV
022  49  PRD
023  04   04
024  00   0
025  32  X:T
026  43  RCL
027  04   04
028  58  FIX
029  00   00
030  67   EQ
031  11   A
032  42  STO
033  04   04
034  49  PRD
035  04   04
036  43  RCL
037  04   04
038  99  PRT
039  58  FIX
040  02   02
041  76  LBL
042  11   A
043  01   1
044  42  STO
045  04   04
046  92  RTN
047  76  LBL
048  12   B
049  91  R/S
050  91  R/S
051  22  INV
052  44  SUM
053  04   04
054  92  RTN
055  76  LBL
056  13   C
057  73  RC*
058  03   03
059  65   x
060  93   .
061  00   0
062  00   0
063  00   0
064  00   0
065  00   0
066  01   1
067  95   =
068  42  STO
069  04   04
070  92  RTN
071  76  LBL
072  14   D
073  73  RC*
074  03   03
075  42  STO
076  05   05
077  43  RCL
078  05   05
079  65   x
080  93   .
081  00   0
082  00   0
083  00   0
084  00   0
085  00   0
086  01   1
087  95   =
088  52  EE
089  22  INV
090  52  EE
091  65   x
092  01   1
093  00   0
094  00   0
095  00   0
096  00   0
097  00   0
098  00   0
099  95   =
100  22  INV
101  44  SUM
102  05   05
103  43  RCL
104  05   05
105  92  RTN
106  01   1
107  44  SUM
108  03   03
109  01   1
110  94  +/-
111  32  X:T
112  43  RCL
113  03   03
114  75   -
115  01   1
116  00   0
117  00   0
118  95   =
119  67   EQ
120  91  R/S
121  61  GTO
122  00   00
123  08   08
```

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324.	02	8000006.	43	3000006.	85
6.	03	8000006.	44	2000024.	86
0.	04	78000006.	45	28000012.	87
0.	05	14000006.	46	21000024.	88
63000020.	06	14000006.	47	3000012.	89
32000024.	07	28000006.	48	5000006.	90
40000024.	08	15000001.	49	5000006.	91
12000006.	09	67000024.	50	2000006.	92
40000024.	10	24000024.	51	40000024.	93
24000012.	11	4000006.	52	102000060.	94
8000006.	12	11000006.	53	30000144.	95
5000012.	13	40000048.	54	18000024.	96
69000012.	14	35000005.	55	338000040.	97
14000006.	15	8000020.	56	16000024.	98
95000006.	16	60000060.	57	25000160.	99
30000006.	17	68000040.	58		
72000006.	18	15000024.	59		
64000024.	19	4000012.	60		
48000048.	20	24000024.	61		
124000048.	21	96000006.	62		
5000006.	22	48000024.	63		
40000006.	23	02000006.	64		
24000006.	24	1000006.	65		
16000006.	25	8000024.	66		
21000006.	26	6000024.	67		
7000006.	27	19000024.	68		
24000006.	28	37000024.	69		
100000024.	29	38000024.	70		
36000012.	30	37000024.	71		
16000024.	31	14000024.	72		
48000012.	32	14000024.	73		
36000012.	33	8000006.	74		
73000012.	34	63000020.	75		
20000024.	35	12000024.	76		
120000024.	36	8000006.	77		
36000006.	37	6000006.	78		
61000006.	38	30000006.	79		
42000024.	39	15000006.	80		
80000024.	40	12000024.	81		
		7000006.	82		

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